



## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
06.10.2004 Bulletin 2004/41

(51) Int Cl.7: A61F 9/007, A61M 1/00

(21) Application number: 04405199.3

(22) Date of filing: 02.04.2004

(84) Designated Contracting States:  
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR  
HU IE IT LI LU MC NL PL PT RO SE SI SK TR  
Designated Extension States:  
AL HR LT LV MK

• Nallakrishnan, Ravi  
Westmont, IL 60559 (US)

(72) Inventor: Akahoshi, Takayuki  
Tokyo 101-8643 (JP)

(30) Priority: 04.04.2003 US 406571

(74) Representative: Clerc, Natalia et al  
Isler & Pedrazzini AG  
Postfach 6940  
8023 Zürich (CH)

(71) Applicants:  
• Akahoshi, Takayuki  
Tokyo 101-8643 (JP)

## (54) Phacoemulsification needle

(57) A phacoemulsification needle according to the invention comprises a shaft, a tip disposed at a distal end of said shaft and an aspiration lumen extending through said shaft and said tip. The tip has an opening

communicating with said aspiration lumen. The shaft comprises at least a portion which has a ribbed outer surface. This needle minimizes heat generation and can therefore be used with or without sleeve.

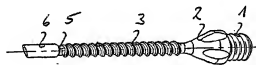


Fig. 1a

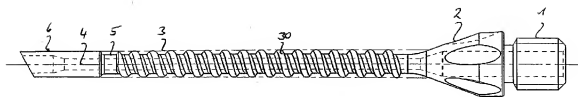


Fig. 15

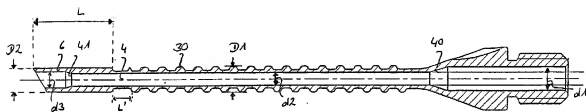


Fig. 1c

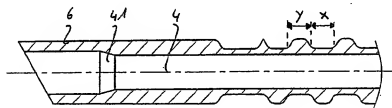


Fig. 1d

## Description

### Field of the invention

[0001] This invention relates to a phacoemulsification needle for an ultrasonic surgical instrument, the needle being designed for promoting cavitation in eye tissue and for the removal of fragmented lens from the eye.

### Background of the invention

[0002] Phacoemulsification has become the preferred form of cataract, i.e. a cloudy eye lens, removal. One of the main advantages of phacoemulsification is, that only a small incision into the cornea or sclera of an eye is needed to remove the cataract. Furthermore, the removal of the cataract can be done very quickly. After the cataract is removed, an intraocular lens is inserted to replace the original lens.

[0003] The phacoemulsification technique uses a hand held microsurgical tool known as phacoemulsifier. This phacoemulsifier comprises a handpiece and a small diameter needle with a tip to be inserted into the small incision of the eye. The needle and therefore the tip are vibrated by an ultrasonic source. It breaks the cataract into small fragments and pieces, which are sucked out through the same tip in a controlled manner. The tip is therefore designed for emulsifying, fragmenting and/or cutting tissue and also comprises a central hollow bore or lumen for the suction or aspiration of the fragments.

[0004] During the procedure, an irrigation solution is introduced to maintain the pressure and to prevent the eye from collapsing. In order to introduce the irrigation solution, the needle is usually covered by a sleeve and the solution flows via the space between this sleeve and the needle. The solution is therefore also used to cool the tip, which is heating up during the phacoemulsification.

[0005] Heat generated by the needle or tip degenerates the collagen of the cornea or sclera in the wound. If the collagen is degenerated by the heat, the wound will be damaged and cannot be self-sealed at the end of the surgery. An unsealed wound can cause anterior chamber collapse, which will result in severe corneal endothelial cell damage and most serious intraocular infection. Suturing the heat damaged tissue may attain sealing of the wound, however, it will cause deformity of the cornea and result in the large post-operative astigmatism. Thus decreasing the risk of the thermal damage of the wound by the tip is one of the most important points of cataract surgery by phacoemulsification.

[0006] US-A-5'653'724 discloses a phacoemulsification needle which is angled to provide a more comfortable ergonomic angle during phacoemulsification and lens cortex removal. This angled needle is also considered to produce less heat when emulsifying the lens. Another angled phacoemulsification needle with a con-

centric sleeve is disclosed in US-5'993 409.

[0007] Different shapes of phacoemulsification needles with slits, a second infusion hole and/or with increased outside diameter at the distal end of the needle body and the needles being surrounded by sleeves are described in US-A-5'989'209, US-A-5'159'175, EP-A-1'103'238, WO 00/74615 and US 2002/0099325. US-A-5'989'209 furthermore discloses the use of a ribbed insert together with a sleeve. This shall permit continued irrigation fluid flow while reducing the contact area between the sleeve and the ribbed insert, thereby reducing the risk of thermal damage to the entry wound of the eye.

[0008] Other techniques for cataract removal use laser energy to remove the cataract. A laser/aspiration probe is used for breaking and removing the lens. A separate infusion or irrigation probe is used for the irrigation solution.

### Summary of the invention

[0009] It is an object of the invention to provide a phacoemulsification needle which minimizes the heat generation and which can therefore also be used without a sleeve.

[0010] This object is achieved with a phacoemulsification needle comprising

a shaft,  
a tip, disposed at a distal end of said shaft and  
an aspiration lumen extending through said shaft  
and said tip, the tip having an opening communicating with said aspiration lumen,

wherein said shaft comprises at least one portion having a ribbed outer surface.

[0011] Since the shaft comprises ribs, preferably in spiral or helical form, the surface of the tip is increased and the cooling effect of the tip is markedly enhanced.

[0012] The needle according to the invention can be used with or without an irrigation sleeve.

[0013] In a preferred embodiment, the tip comprises a slit extending in longitudinal direction of the needle. When a high vacuum setting is used with the phacoemulsifier, the anterior chamber, formed of the part of the lumen extending in the tip, becomes unstable when occlusion break occurs. In this case, small amount of irrigation fluid will continue to flow through the aspiration lumen. Furthermore, when occlusion surge occurs, the amount of surge can be reduced.

[0014] Further preferred embodiments of the invention are described in the dependent claims.

### Brief description of the drawings

[0015] The present invention will be more clearly understood with reference to the following detailed description of preferred embodiments, taken in conjunction with the accompanying drawings, in which

Figure 1a shows a perspective view of a needle according to the invention in a first embodiment,  
 Figure 1b the needle according to figure 1a in a side view,  
 Figure 1c in another side view,  
 Figure 1d shows a magnified part of the needle tip according to figure 1c;  
 Figure 2a shows a perspective view of a needle according to the invention in a second embodiment,  
 Figure 2b the needle according to figure 2a in a side view,  
 Figure 2c in another side view,  
 Figure 2d shows a magnified front view of the needle according to figure 2a;  
 Figure 2e shows a front view of the needle according to figure 2d;  
 Figure 3a shows a perspective view of a needle according to the invention in a third embodiment,  
 Figure 3b the needle according to figure 3a in a side view,  
 Figure 3c in another side view,  
 Figure 3d shows a magnified front view of the needle according to figure 3a and  
 Figure 4a shows a perspective view of a needle according to the invention in a fourth embodiment,  
 Figure 4b the needle according to figure 4a in a side view,  
 Figure 4c in another side view,  
 Figure 4d shows a magnified front view of the needle according to figure 4a.

### Description of the preferred embodiments

[0016] With reference to figures 1a and 1b, there is shown a phacoemulsification needle in accordance with the present invention. The needle may be formed from any conventional material as is known in the art for the manufacture of phacoemulsification needles. Usually, it is made of titan.

[0017] The needle comprises, starting with its proximal end and ending with its distal end, a threaded portion 1, a hub 2, a shaft 3 and a tip 6 having an opening. The threaded portion 1 and the hub 2 form a joint end enabling the needle to be fixed to an ultrasonic device of the phacoemulsification handpiece (not shown) in order to couple ultrasonic energy to the needle.

[0018] The needle further comprises, with reference to figures 1c and 1d, an aspiration lumen 4 extending through the whole longitudinal length of the needle shaft 3 and communicating with the opening of the tip for aspiration of irrigation fluid and therefore for removal of fragments and pieces of the cataract. Preferably, the lumen 4 comprises a first step 40 in the region of the hub 2 neighboring the shaft 3. The first diameter d1 of the

part of the lumen extending within the hub 2 is therefore larger than the second diameter d2 of the lumen part extending within the shaft 2. This first step 40 has preferably a conical shape.

[0019] A second step 41, which has preferably also a conical shape, is located within the tip 6, wherein the second diameter d2 is smaller than a third diameter d3 of the lumen part extending within the shaft 2. The width of the opening of the tip is even larger than the third diameter d3.

[0020] With exception of the steps 40, 41, the lumen preferably has throughout its whole length the same size. In particular the lumen part extending in the tip 6 has a cylindrical shape.

[0021] In this embodiment, the shaft 3 is rectilinear. The shaft 3 comprises at least one portion which has a ribbed outer surface 30. These ribs extending radially from the outer side of the shaft are preferably built by spiral ridges or a helix. Other protrusions are however possible. This portion extends preferably at least approximately along the whole length of the shaft 3.

[0022] Disposed between this portion with the ribbed surface 30 and the tip 6 is a tapered portion 5, connecting these two. The tip 6, which is disposed at the distal end of the shaft 3, has preferably at least approximately the same outer diameter D2 as the outer diameter D1 of the shaft 3. The above mentioned second step 41 is preferably located in the tip 6 itself at a distance to the transition of the ball-shaped surface 60 to the surface of the shaft 3.

[0023] A preferred embodiment of the inventive needle has an outer diameter D1 of the shaft 2 and an outer diameter D2 of the tip of approximately 1.32 mm, an inner diameter D1' of the shaft 3 of approximately 0.956 mm, a first diameter d1 of the lumen 4 of approximately 1.32 mm, a second diameter d2 of approximately 0.72 mm, a third diameter d3 of approximately 0.9 mm, a length L of the tip 5 of approximately 4.385 mm and a distance x from the frontal end to the second step 41 of approximately 1.8 mm. The distance X between two ribs is approximately 0.5 mm, the thickness Y of a rib is also approximately 0.5 mm. The length L' of the tapered portion 5 is approximately 0.8 mm, wherein the transition areas between the tapered portion and the tip and the tapered portion and the shaft respectively comprise an angle of 30° each. The angle  $\alpha$  of the first step 40 is approximately 34° and the angle  $\beta$  of the second step 41 approximately 30°. The total length of the needle is approximately 30 mm.

[0024] Figures 2a to 2d show a second preferred embodiment of the needle according to the invention. The needle is built in the same way as the needle according to the previously described figures. The only difference is, that this tip 6 comprises a slit 7 extending in longitudinal direction of the needle, which communicates with the aspiration lumen 4. This slit can be best seen in figures 2d and 2e.

[0025] Figures 3a to 3d show a third preferred embod-

iment being similar to the embodiment according to figures 1a to 1d without the slit 7 and Figures 4a to 4d show a fourth preferred embodiment being similar to the embodiment according to figures 2a to 2d comprising the slit 7. The only difference to these figures is, that in the third and fourth embodiments the tip 6 is angled. The tip 6 consists of an extension portion 60 being disposed at the distal end of the tapered portion 5, followed by an angled portion 61 and an end portion 62. The end portion 62 has a flared end surface like the end portions of the first and second embodiments. This forms a large port or opening which can remove the lens material most efficiently, whereas the smaller diameter of the tip contributes to the stability of the anterior chamber formed by the lumen part within the tip. The angle between extension portion 60 and end portion 62 preferably lays between 17.5° and 20°.

[0026] In another preferred embodiment, the ribs or grooves can also be located on the inner wall of the lumen 4. These inner ribs or grooves can be an additional feature of a tip having the outer ribs, helix or grooves. However, the tip can also comprise ribs and grooves on the inner side only and the outer surface can be smooth.

[0027] The needle according to the invention minimizes heat generation and can therefore be used with or without sleeve.

#### List of reference numbers

##### [0028]

1 threaded portion  
2 hub  
3 shaft  
30 ribbed outer surface  
4 lumen  
40 first step  
41 second step  
5 tapered portion  
6 tip  
60 extension portion  
61 angled portion  
62 end portion  
7 slit  
d1 first diameter  
d2 second diameter  
d3 third diameter  
D1 outside diameter of the shaft  
D2 outside diameter of the tip  
L length of the tip  
L' length of tapered portion  
X distance between two ribs  
Y thickness of a rib

a shaft,  
a tip, disposed at a distal end of said shaft and an aspiration lumen extending through said shaft and said tip, the tip having an opening communicating with said aspiration lumen,

wherein said shaft comprises at least one portion having a ribbed outer surface.

2. The needle according to claim 1, wherein said ribbed outer surface is formed by spiral ridges or a helix.

3. The needle according to claim 1, wherein said tip has an outer diameter being at least approximately the same as an outer diameter of said ribbed outer surface of said shaft.

4. The needle according to claim 1, wherein the needle comprises a tapered portion connecting said ribbed outer surface and said tip.

5. The needle according to claim 1, wherein said ribbed outer surface extends at least approximately along the whole length of said shaft.

6. The needle according to claim 1, wherein the tip is angled.

7. The needle according to claim 1, wherein said opening has a larger diameter than the part of the aspiration lumen extending within said shaft.

8. The needle according to claim 1, wherein said aspiration lumen comprises a conical step within the tip.

9. The needle according to claim 8, wherein said conical step has an angle of approximately 30°.

10. The needle according to claim 1, wherein said tip comprises a slit extending in longitudinal direction of the needle and communicating with said aspiration lumen.

#### Claims

1. A phacoemulsification needle comprising



Fig. 1a

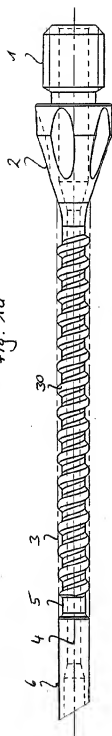


Fig. 1b

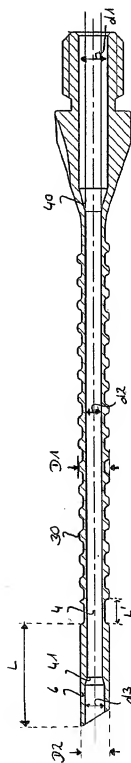


Fig. 1c

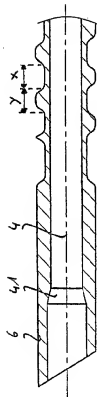


Fig. 1d



Fig. 2a

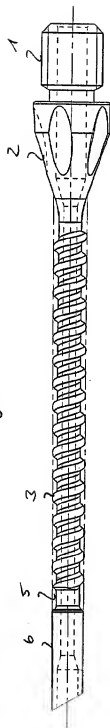


Fig. 2b

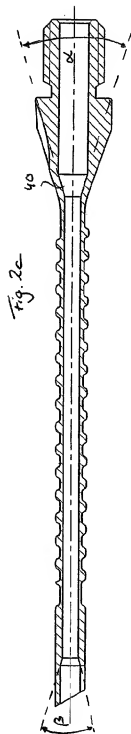


Fig. 2c

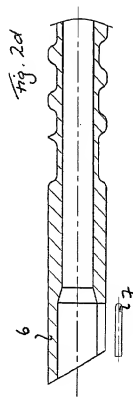


Fig. 2d

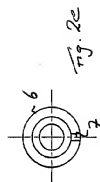


Fig. 2e

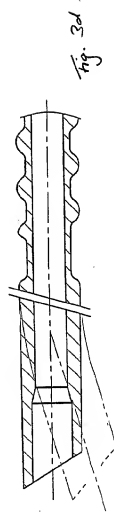
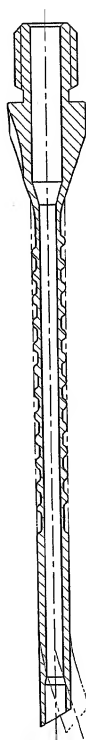
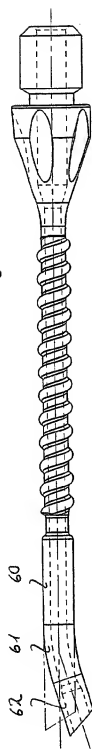






Fig. 4a

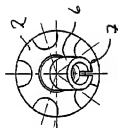


Fig. 4d

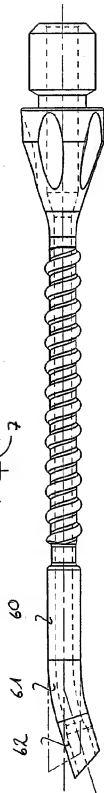


Fig. 4b

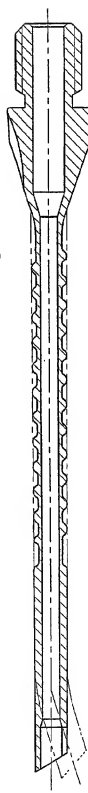


Fig. 4c



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 04 40 5199

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,X	US 5 989 209 A (BARRETT GRAHAM D) 23 November 1999 (1999-11-23)	1-5,7-9	A61F9/007 A61M1/00
Y	* column 3, line 19 - line 32 * * column 4, line 7 - line 56 * * column 5, line 19 - line 35 * * column 5, line 55 - line 65; claims 1-14; figures 2-5,7,8 * ---	6,10	
X	US 6 340 355 B1 (BARRETT GRAHAM DAVID) 22 January 2002 (2002-01-22) * column 3, line 37 - line 44 * * column 4, line 3 - line 17 * * column 5, line 12 - line 44; claims 10,11; figures 6,8-11 * ---	1,3-6,8,9	
D,Y	US 2002/099325 A1 (KADZIAUSKAS KENNETH E ET AL) 25 July 2002 (2002-07-25) * paragraphs [0005], [0007], [0008], [0011]-[0015], [0026]-[0028], [0032]-[0035]; claims 1,4,5; figures 2-6 * ---	6	
Y	US 5 464 389 A (STAHL NORMAN O) 7 November 1995 (1995-11-07) * column 5, line 16 - line 49; claims 7-9; figures 5,6,8,9 * -----	10	
The present search report has been drawn up for all claims			
Place of search <b>MUNICH</b>		Date of completion of the search <b>24 June 2004</b>	Examiner <b>Rick, K</b>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons * : member of the same patent family, corresponding document</p>			

EPO FORM 1502 03/02 (P4/051)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 40 5199

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-06-2004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5989209	A	23-11-1999	AT 245013 T	15-08-2003
			AU 684224 B2	04-12-1997
			AU 3336595 A	27-03-1996
			WO 9607377 A1	14-03-1996
			CA 2198259 A1	14-03-1996
			DE 69531304 D1	21-08-2003
			DE 69531304 T2	04-03-2004
			EP 1371347 A2	17-12-2003
			EP 0778757 A1	18-06-1997
			ES 2200002 T3	01-03-2004
			IL 115139 A	30-11-1999
			IN 185723 A1	14-04-2001
			JP 3280671 B2	13-05-2002
			JP 10507655 T	28-07-1998
			US 5718676 A	17-02-1998
			US 5935096 A	10-08-1999
			ZA 9507375 A	17-04-1996
US 6340355	B1	22-01-2002	AU 717553 B2	30-03-2000
			AU 3841497 A	06-03-1998
			WO 9807398 A1	26-02-1998
			EP 0928177 A1	14-07-1999
			US 2002019605 A1	14-02-2002
US 2002099325	A1	25-07-2002	NONE	
US 5464389	A	07-11-1995	NONE	

EPO FORM 1060

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82